A-6 PREVENTING INFILTRATION FROM THE BIG LOST RIVER AND REDUCING ANTHROPOGENIC WATER RECHARGE BY 50%

As shown in Section A-3, infiltration from the Big Lost River primarily influences transport in northern INTEC, while the anthropogenic water losses influence transport throughout INTEC as shown in Section A-2. Reducing infiltration from the Big Lost River alone resulted in a marginal improvement of 1.1 pCi/L in peak aquifer concentrations relative to the RI/BRA base case, with most of that occurring after 2050. Reducing anthropogenic water losses improved the peak concentration by 4.2 pCi/L, with gains realized through the 2008-2095 time period. The purpose of this simulation is to determine the effect of preventing infiltration from the middle reach of the Big Lost River after year 2010 in addition to removing 50% of the anthropogenic water within the INTEC fence by year 2008.

A-6-1 Aquifer Sr-90 Simulation Results

Predicted Sr-90 concentrations in the aquifer through year 2096 on the course grid are shown in Figure A-6-1 and through the year 2151 on the fine grid in Figure A-6-2. These can be compared to the RI/BRA base case results shown in Figures J-8-18 and J-8-19 [DOE-NE-ID 2006]. Resultant peak aquifer concentrations for both simulations are shown in Figure A-6-3, with this simulation shown in red and the RI/BRA base case shown in black. The first two performance measures are summarized in Table A-6-1.

Simulation	Peak 2095 Concentration (pCi/L)	Year Concentration < 8 pCi/L
RI/BRA base case [DOE-NE-ID 2006]	18.6	2129
Preventing infiltration from the Big Lost River	17.5	2121
Removing 50% of anthropogenic water	14.4	2122
Preventing infiltration from the Big Lost River and removing 50% of the anthropogenic water	13.5	2115

Table A-6-1. Summary: Preventing infiltration from the Big Lost River and removing 50% of the anthropogenic water

As a result of removing both of these water sources, the results are nearly additive as shown by the peak aquifer concentration of 13.5 pCi/L. This is somewhat surprising because the Big Lost River affects northern Sr-90 migration, and the anthropogenic water is almost uniformly distributed throughout INTEC. The gains in this performance measure occur as a result of reducing the fluxes in southern INTEC overlying the high perched water concentrations in addition to reducing the incoming Sr-90 from the north.

Reducing the vertical velocity allows more decay to occur, which reduces aquifer concentrations. It also delays the arrival of all of the Sr-90 from the vadose zone. At the same time, reducing the incoming fresh water prevents dilution in the deep vadose zone and aquifer, which increases concentrations. The competing effects in this case keep the Sr-90 concentrations above the MCL through year 2115, allowing them to fall below the MCL sooner than either removing the anthropogenic water or preventing infiltration from the Big Lost River alone.

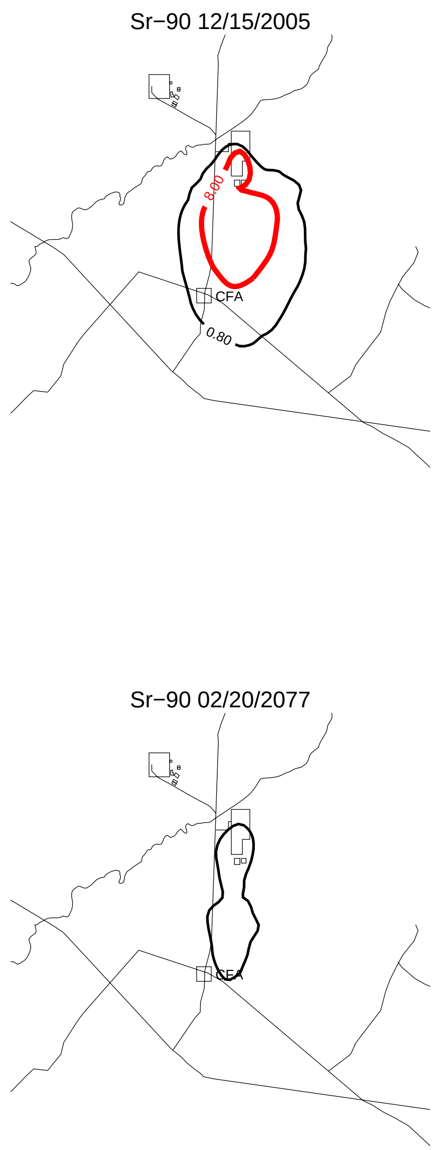

Figure A-6-1. Aquifer concentrations preventing infiltration from the Big Lost River and removing 50% of the anthropogenic water (horizontal contours) (pCi/L) (MCL = thick red line, 10*MCL=thin red line, MCL/10 = black line).

Figure A-6-2. Aquifer concentrations preventing infiltration from the Big Lost River and removing 50% of the anthropogenic water (horizontal contours) (pCi/L) (continued) (MCL = thick red line, 10*MCL=thin red line, MCL/10 = black line).

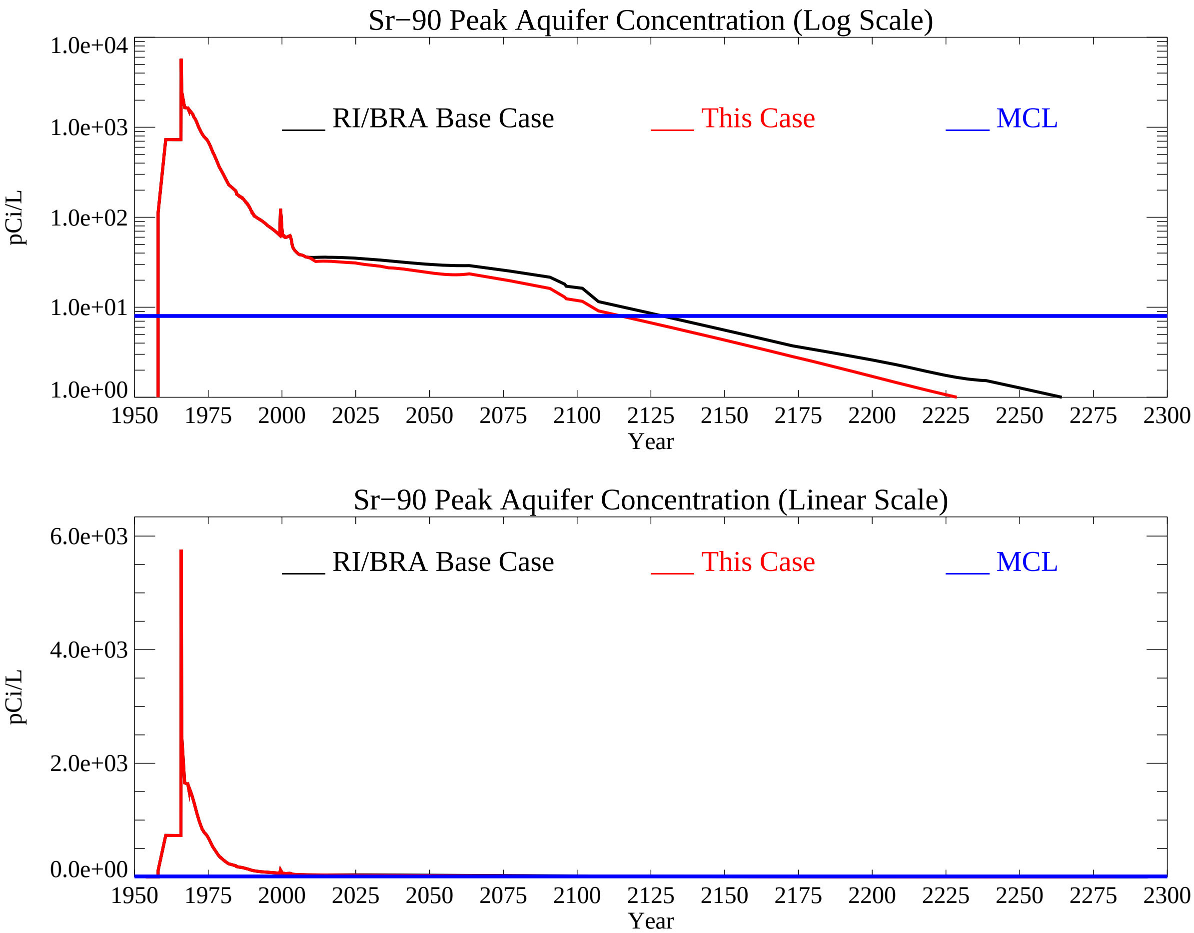

Figure A-6-3. Peak aquifer concentrations preventing infiltration from the Big Lost River and removing 50% of the anthropogenic water (pCi/L) (MCL = blue line, model predicted = black line [base case] and red line [this case]).

A-7 PREVENTING INFILTRATION FROM THE BIG LOST RIVER AND REDUCING INFILTRATION THROUGH THE 10 ACRES SURROUNDING THE TANK FARM

Reducing infiltration from the Big Lost River affected transport from perched water north of the tank farm and below the 140-ft interbed as shown in Section A-3. This flux reduction allowed concentrations north of the tank farm to fall below 0.8 pCi/L by year 2095. Reducing infiltration through the 10 acres surrounding the tank farm primarily affected transport from the region containing the highest Sr-90 concentrations in the northern upper perched water, with the largest response observed to the south of the tank farm.

The purpose of this simulation is to determine the effect of preventing infiltration from the Big Lost River after 2010, in addition to reducing infiltration through the 10 acres surrounding the tank farm after year 2008.

A-7-1 Aquifer Sr-90 Simulation Results

Predicted Sr-90 concentrations in the aquifer through year 2096 on the course grid are shown in Figure A-7-1 and through the year 2151 on the fine grid in Figure A-7-2. These can be compared to the RI/BRA base case results shown in Figures J-8-18 and J-8-19 [DOE-NE-ID 2006]. Resultant peak aquifer concentrations for both simulations are shown in Figure A-7-3, with this simulation shown in red and the RI/BRA base case shown in black. The first two performance measures are summarized in Table A-7-1.

Simulation	Peak 2095 Concentration (pCi/L)	Year Concentration < 8 pCi/L
RI/BRA base case [DOE-NE-ID 2006]	18.6	2129
Preventing infiltration from the Big Lost River	17.5	2121
Reducing infiltration through the 10 acres surrounding the tank farm	7.9	2095
Preventing infiltration from the Big Lost River and reducing infiltration through the 10 acres surrounding the tank farm	7.3	2094

Table A-7-1. Summary: Preventing infiltration from the Big Lost River and reducing infiltration through the 10 acres surrounding the tank farm.

The results of this combination are not linearly additive, as shown by the peak aquifer concentration of 7.3 pCi/L and by the 2094 year through which the MCL is exceeded. Reducing fluxes from the Big Lost River produces gains in peak aquifer concentration after the 2050 time period, while reducing infiltration near the tank farm produces early results. Northern Big Lost River fluxes affect low concentrations between the 0.8 pCi/L and 8.0 pCi/L levels, while the southern fluxes affect higher concentrations underlying the tank farm. The overlap between the two infiltration regions is small, and the combined action produces modest gains compared to simply reducing infiltration surrounding the tank farm.

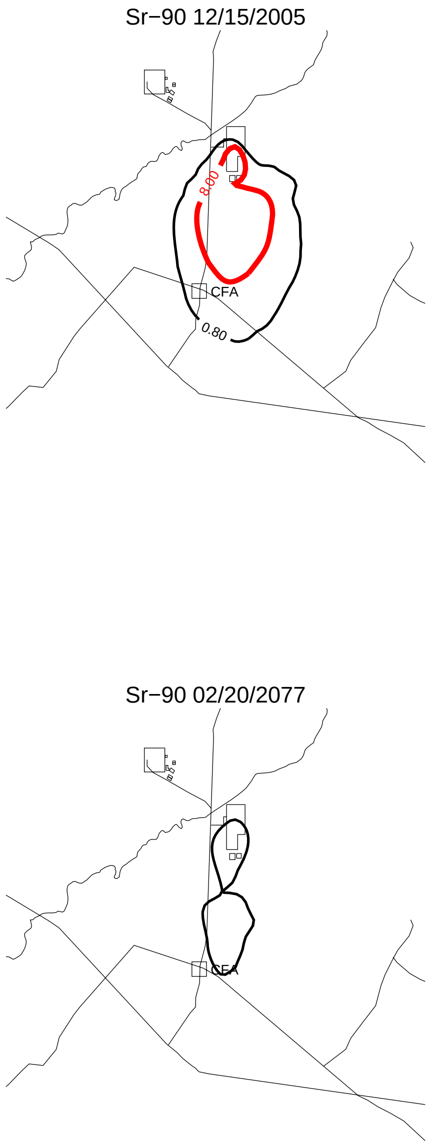

Figure A-7-1. Aquifer concentrations preventing infiltration from the Big Lost River in addition to reducing infiltration through the 10 acres surrounding the tank farm (horizontal contours) (pCi/L) (MCL = thick red line, 10*MCL=thin red line, MCL/10 = black line).

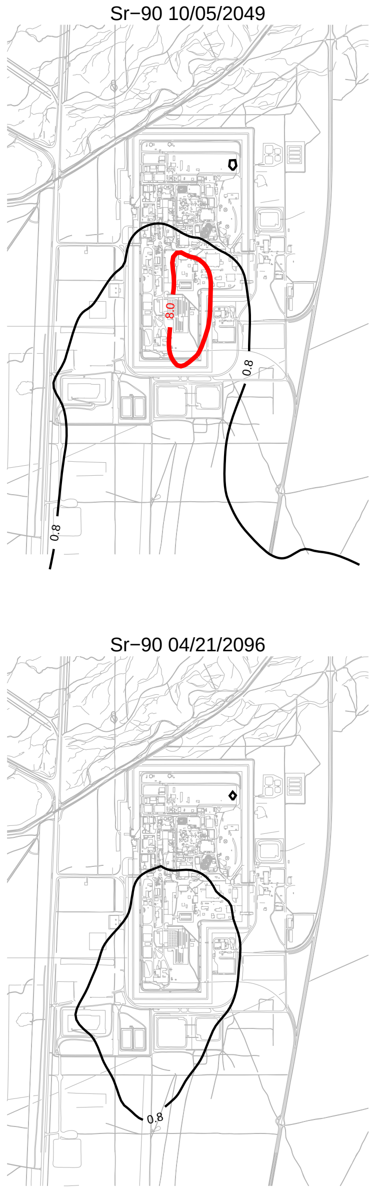

Figure A-7-2. Aquifer concentrations preventing infiltration from the Big Lost River in addition to reducing infiltration through the 10 acres surrounding the tank farm (horizontal contours) (pCi/L) (continued) (MCL = thick red line, 10*MCL=thin red line, MCL/10 = black line).

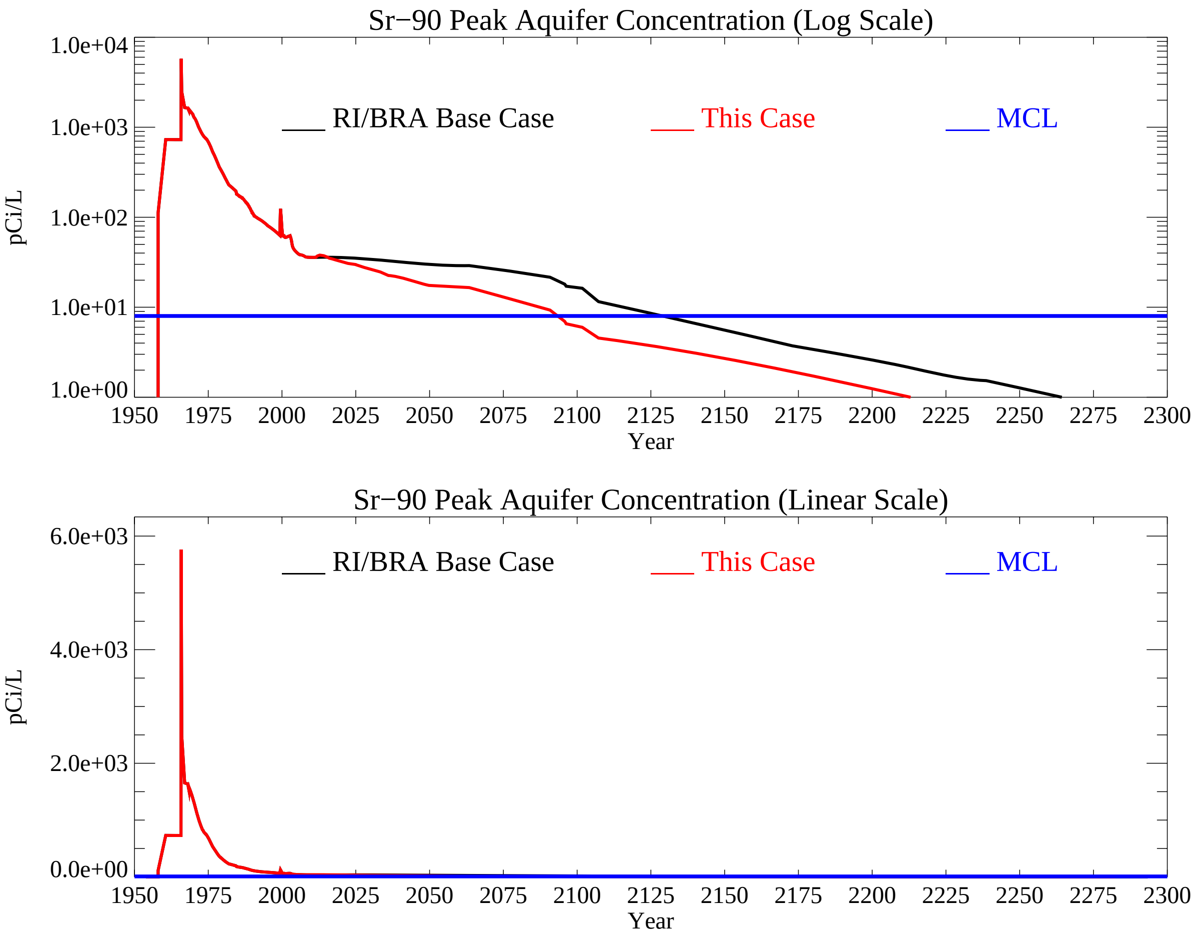

Figure A-7-3. Peak aquifer concentrations preventing infiltration from the Big Lost River in addition to reducing infiltration through the 10 acres surrounding the tank farm (pCi/L) (MCL = blue line, model predicted = black line [base case] and red line [this case]).

A-8 REDUCING ANTHROPOGENIC WATER RECHARGE BY 50% AND REDUCING INFILTRATION THROUGH THE 10 ACRES SURROUNDING THE TANK FARM

Reducing the anthropogenic water losses alone results in modest decreases in the Sr-90 flux from the vadose zone. Reducing infiltration through the 10 acres surrounding the tank farm also assumed that the anthropogenic water losses were removed entirely from that area. The combination evaluated in this simulation reduces infiltration through the 10 acres surrounding the tank farm by 2012 and reduces the remaining anthropogenic water losses by 50% in year 2008.

A-8-1 Aquifer Sr-90 Simulation Results

Predicted Sr-90 concentrations in the aquifer through year 2096 on the course grid are shown in Figure A-8-1 and through the year 2151 on the fine grid in Figure A-8-2. These can be compared to the RI/BRA base case results shown in Figures J-8-18 and J-8-19 [DOE-NE-ID 2006]. Resultant peak aquifer concentrations for both simulations are shown in Figure A-8-3, with this simulation shown in red and the RI/BRA base case shown in black. The first two performance measures are summarized in Table A-8-1.

Simulation	Peak 2095 Concentration (pCi/L)	Year Concentration < 8 pCi/L
RI/BRA base case [DOE-NE-ID 2006]	18.6	2129
Reducing anthropogenic water recharge by 50%	14.4	2122
Reducing infiltration through the 10 acres surrounding the tank farm	7.9	2095
Reducing anthropogenic water recharge by 50% and reducing infiltration through the 10 acres surrounding the tank farm	6.5	2091

Table A-8-1. Summary: Reducing anthropogenic water recharge by 50% and reducing infiltration through the 10 acres surrounding the tank farm

As a result of removing both of these water sources, the results are not linearly additive as shown by the peak aquifer concentration of 6.5 pCi/L and by the 2091 year through which the MCL is exceeded. Because reducing infiltration through the tank farm and reducing the spatially distributed anthropogenic water produce an immediate decrease in peak aquifer concentrations and because of the spatial overlap in affected area, an additive effect would be expected. However, note that the decrease in peak concentration and in time during which the MCL is exceeded in both cases is not in proportion to the total water volume removed in each case:

- Reducing anthropogenic water losses by 50% essentially removes 2 cm/yr from the infiltration total, with this reduction occurring throughout INTEC.
- Reducing infiltration to 0.1 cm/yr in the 10 acres surrounding the tank farm effectively removes 21.9 cm/yr and includes the 4-cm/yr infiltration from anthropogenic water losses.
- Reducing infiltration to 0.1 cm/yr removes roughly 10 times the amount of water but results in less than a three-fold decrease in peak concentration.
- In a linear, or one-dimensional, system removing 10 times the water volume would result in a 10-fold increase in velocity and decay.

The disproportionately smaller gains realized by reducing fluxes in the 10 acres are in part due to existing Sr-90 in the aquifer and in part due to the spatial offset with respect to underlying high vadose zone concentrations. In the “capping” scenario, no effort was made to reduce the infiltration directly through the highest concentrations in the vadose zone. As a result, the infiltration reduction occurs to the west of the tank farm as opposed to being located to the southeast. On the other hand, the anthropogenic water losses are higher to the southeast of the tank farm in the RI/BRA model. Reducing anthropogenic water losses removes much less water, but reduces it over the areas of higher concentrations. This underscores the importance of reducing infiltration over the highest vadose zone concentrations.

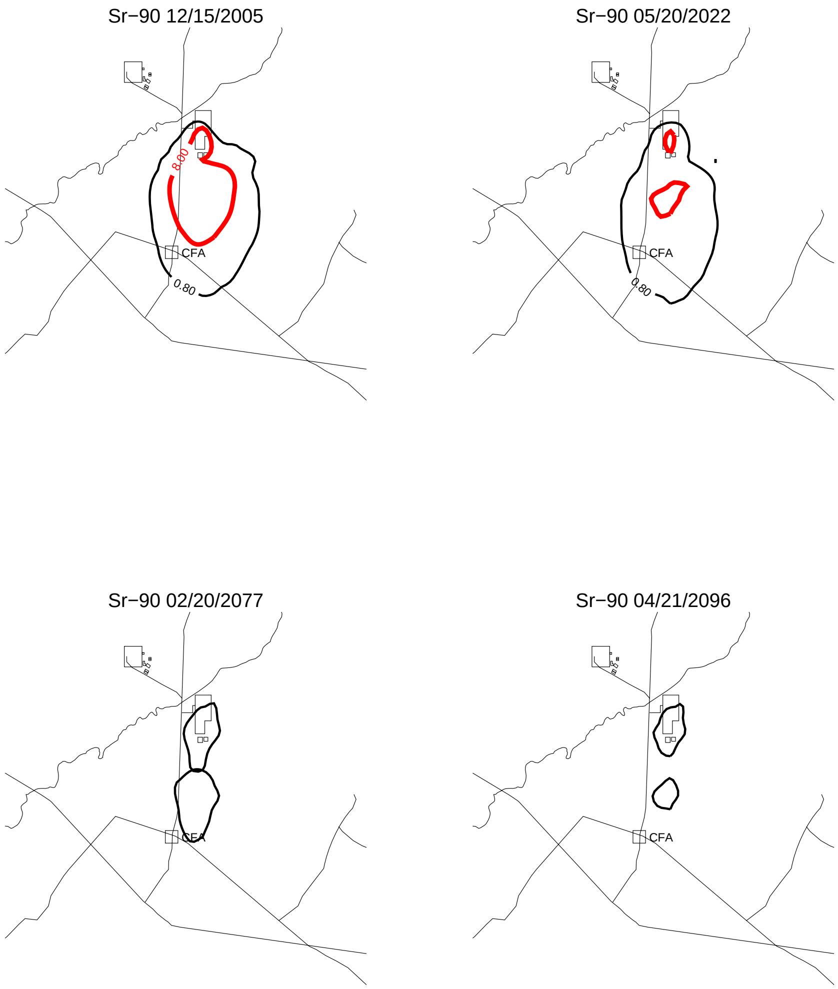

Figure A-8-1. Aquifer concentrations reducing anthropogenic water losses by 50% in addition to reducing infiltration through the 10 acres surrounding the tank farm (horizontal contours) (pCi/L) (MCL = thick red line, 10*MCL=thin red line, MCL/10 = black line).

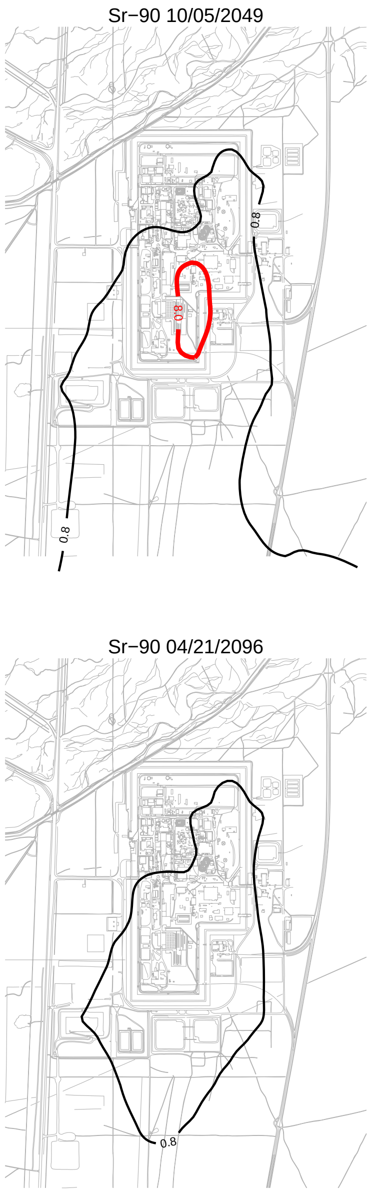

Figure A-8-2. Aquifer concentrations reducing anthropogenic water losses by 50% in addition to reducing infiltration through the 10 acres surrounding the tank farm (horizontal contours) (pCi/L) (continued) (MCL = thick red line, 10*MCL=thin red line, MCL/10 = black line).

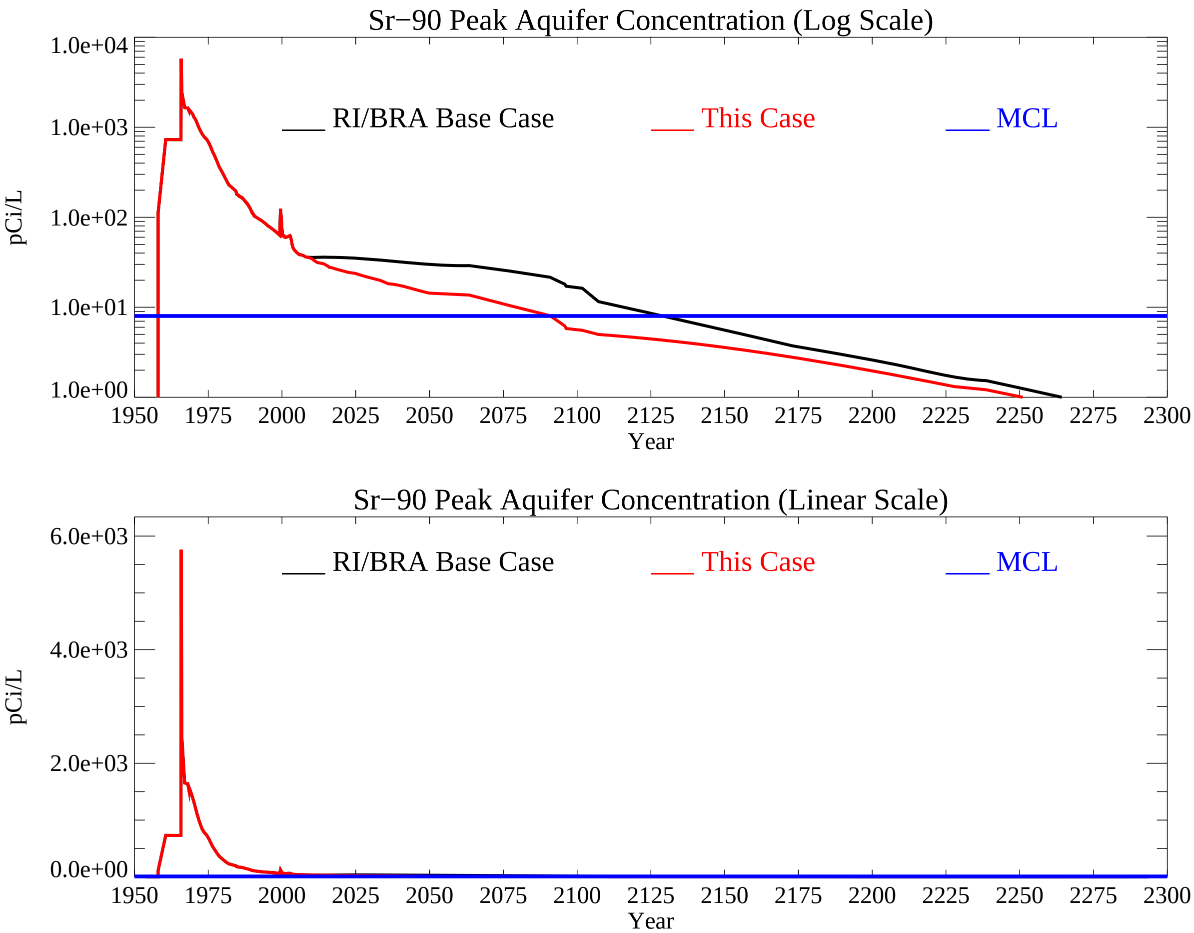

Figure A-8-3. Peak aquifer concentrations reducing anthropogenic water losses by 50% in addition to reducing infiltration through the 10 acres surrounding the tank farm (pCi/L) (MCL = blue line, model predicted = black line [base case] and red line [this case]).

A-9 PREVENTING INFILTRATION FROM THE BIG LOST RIVER, REDUCING ANTHROPOGENIC WATER RECHARGE BY 50%, AND REDUCING INFILTRATION THROUGH THE 10 ACRES SURROUNDING THE TANK FARM

This simulation evaluates the effect of controlling northern recharge from the Big Lost River, reducing anthropogenic water losses throughout INTEC by 50%, and also reducing infiltration through the 10 acres surrounding the tank farm.

A-9-1 Aquifer Sr-90 Simulation Results

Predicted Sr-90 concentrations in the aquifer through year 2096 on the course grid are shown in Figure A-9-1 and through the year 2151 on the fine grid in Figure A-9-2. These can be compared to the RI/BRA base case results shown in Figures J-8-18 and J-8-19 [DOE-NE-ID 2006]. Resultant peak aquifer concentrations for both simulations are shown in Figure A-9-3, with this simulation shown in red and the RI/BRA base case shown in black. The first two performance measures are summarized in Table A-9-1.

Simulation	Peak 2095 Concentration (pCi/L)	Year Concentration < 8 pCi/L
RI/BRA base case [DOE-NE-ID 2006]	18.6	2129
Reducing anthropogenic water recharge by 50%	14.4	2122
Reducing infiltration through the 10 acres surrounding the tank farm	7.9	2095
Preventing recharge from the Big Lost River	17.5	2121
Preventing infiltration from the Big Lost River, reducing anthropogenic water recharge by 50%, and reducing infiltration through the 10 acres surrounding the tank farm	6.0	2089

Table A-9-1. Summary: Preventing Infiltration from the Big Lost River, reducing anthropogenic water recharge by 50% and reducing infiltration through the 10 acres surrounding the tank farm

Adding this third level of water control provides only a slight improvement in peak concentration in year 2095 and only a 2-year improvement in the year concentrations fall below the MCL. This is largely because

- The Big Lost River recharge primarily affects concentrations between 0.8 pCi/L and 8.0 pCi/L in the region north of the tank farm as explained in Sections A-3, A-6, and A-7. Reducing fluxes from the Big Lost River produces the largest improvement in performance measures after year 2050.
- The concentrations are exceeding the MCL primarily to the south of the tank farm under the current RI/BRA parameters. Reducing anthropogenic water losses and controlling infiltration from precipitation produces early improvements in the performance measures.

In order to improve on the results obtained when infiltration near the tank farm is controlled through a combination of anthropogenic water reduction and precipitation reduction, the fluxes further to the southeast of the tank farm would have to be reduced. On the other hand, if the interbed K_d is smaller or if anthropogenic water losses are higher in northern INTEC, Sr-90 is predicted to migrate further north than predicted in the RI/BRA model. Under those two scenarios, controlling fluxes to the north might become more important.

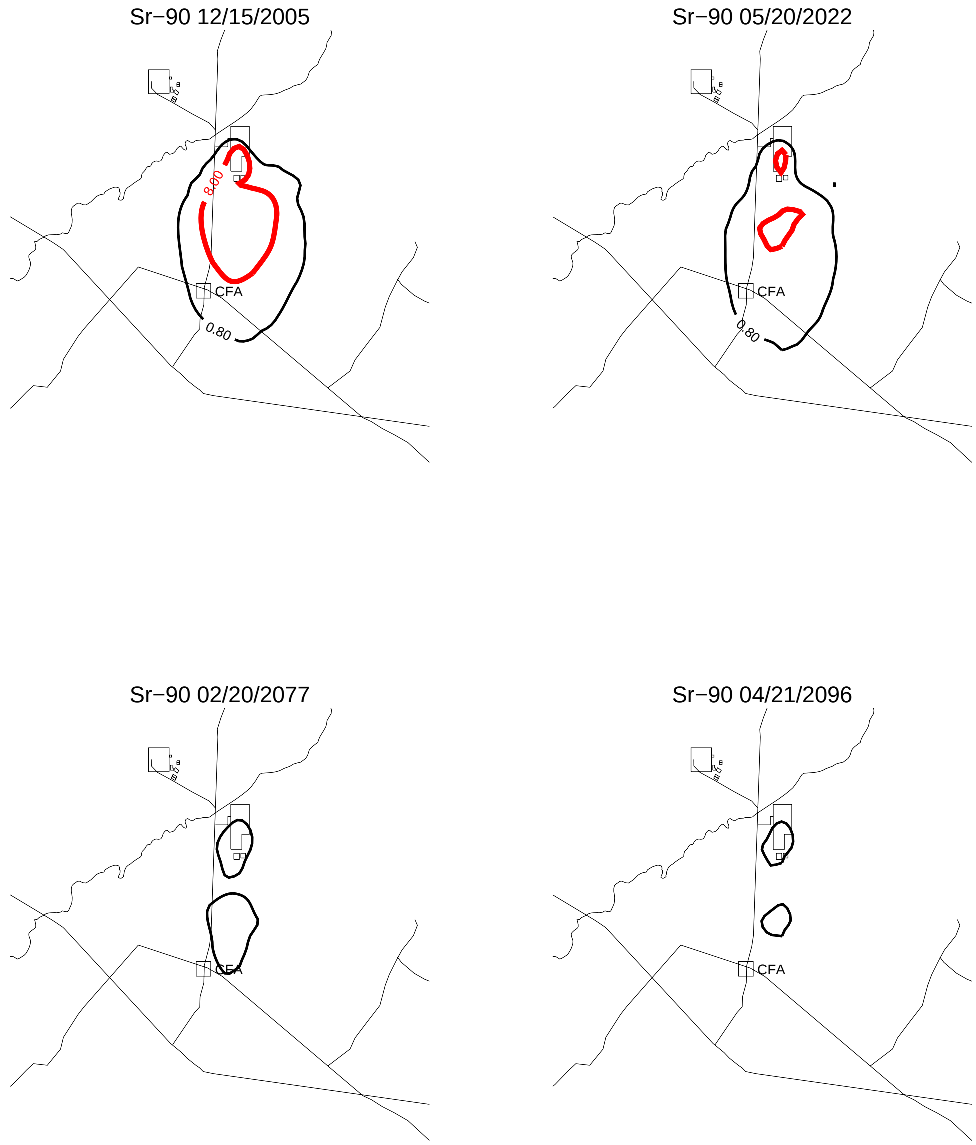

Figure A-9-1. Aquifer concentrations preventing infiltration from the Big Lost River, reducing anthropogenic water losses by 50%, and reducing infiltration through the 10 acres surrounding the tank farm (horizontal contours) (pCi/L) (MCL = thick red line, 10*MCL=thin red line, MCL/10 = black line).

Figure A-9-2. Aquifer concentrations preventing infiltration from the Big Lost River, reducing anthropogenic water losses by 50%, and reducing infiltration through the 10 acres surrounding the tank farm (horizontal contours) (pCi/L) (continued) (MCL = thick red line, 10*MCL=thin red line, MCL/10 = black line).

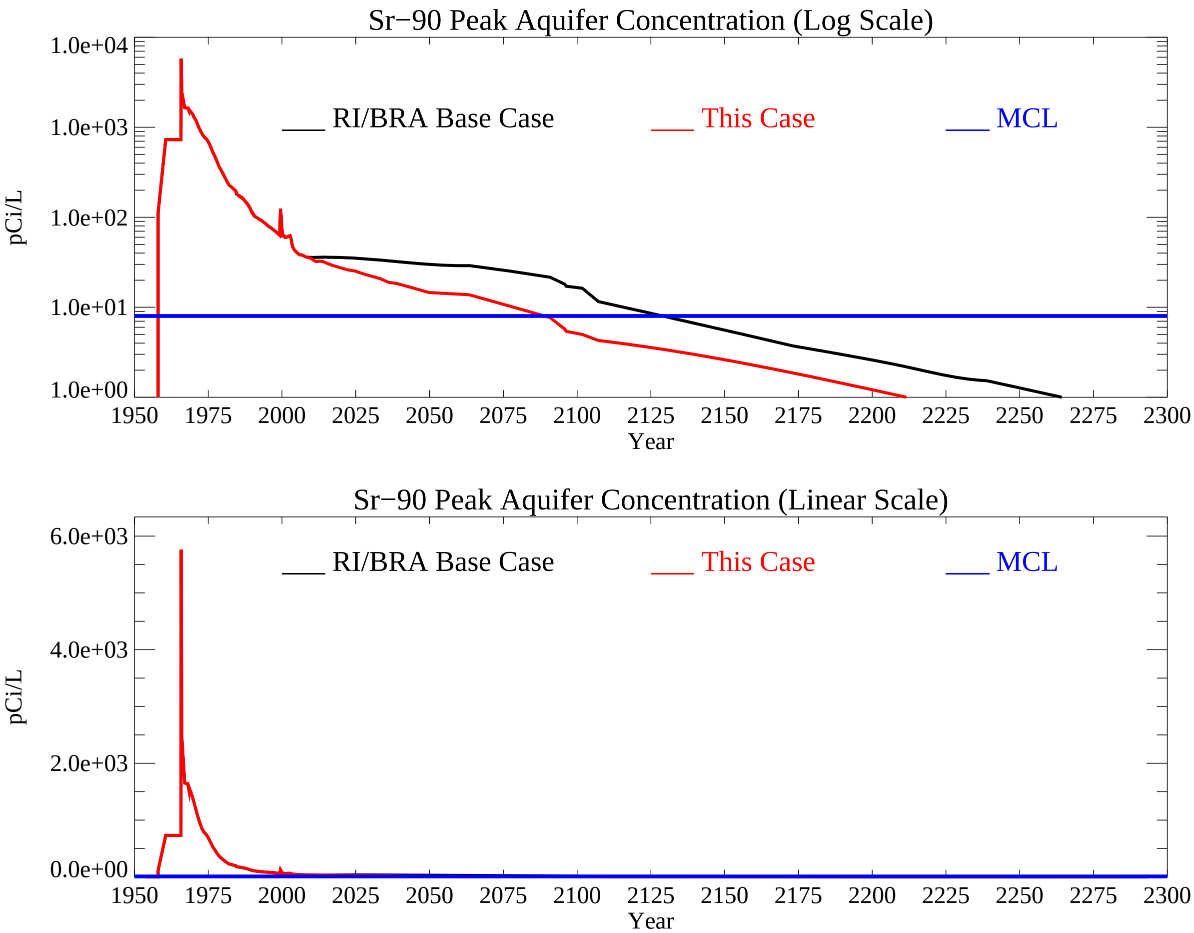

Figure A-9-3. Peak aquifer concentrations preventing infiltration from the Big Lost River, reducing anthropogenic water losses by 50%, and reducing infiltration through the 10 acres surrounding the tank farm (pCi/L) (MCL = blue line, model predicted = black line [base case] and red line [this case]).

A-10 PREVENTING INFILTRATION FROM THE BIG LOST RIVER, REDUCING ANTHROPOGENIC WATER RECHARGE BY 50%, AND IMMOBILIZING Sr-90 IN THE TANK FARM ALLUVIUM

As combined actions, preventing infiltration from the Big Lost River and reducing anthropogenic water losses by 50% resulted in a 5.1 pCi/L decrease in the year 2095 peak aquifer concentration. Immobilizing Sr-90 in the tank farm alluvium reduced peak 2095 aquifer concentrations by 1.7 pCi/L. Peak aquifer concentrations in 2095 predicted by the RI/BRA model were 18.6 pCi/L. This simulation assesses potentially combined impacts from OU 3-13 infiltration controls and the OU 3-14 action of immobilizing Sr-90 in the tank farm. In this simulation, infiltration along the middle reach of the Big Lost River ceases in year 2010, the anthropogenic water losses are achieved by year 2008, and the Sr-90 is immobilized in the tank farm alluvium in year 2008.

A-10-1 Aquifer Sr-90 Simulation Results

Predicted Sr-90 concentrations in the aquifer through year 2096 on the course grid are shown in Figure A-10-1 and through the year 2151 on the fine grid in Figure A-10-2. These can be compared to the RI/BRA base case results shown in Figures J-8-18 and J-8-19 [DOE-NE-ID 2006]. Resultant peak aquifer concentrations for both simulations are shown in Figure A-10-3, with this simulation shown in red and the RI/BRA base case shown in black. The first two performance measures are summarized in Table A-10-1.

Simulation	Peak 2095 Concentration (pCi/L)	Year Concentration < 8 pCi/L
RI/BRA base case [DOE-NE-ID 2006]	18.6	2129
Preventing recharge from the Big Lost River	17.5	2121
Reducing anthropogenic water recharge by 50%	14.4	2122
Immobilizing Sr-90 in the tank farm alluvium	16.9	2122
Preventing infiltration from the Big Lost River, reducing anthropogenic water recharge by 50%, and immobilizing Sr-90 in the tank farm alluvium	12.5	2110

Table A-10-1. Summary: Preventing Infiltration from the Big Lost River, reducing anthropogenic water recharge by 50% and immobilizing Sr-90 in the tank farm alluvium.

Infiltration controls to the north in the form of removing Big Lost River recharge allows a modest gain in peak aquifer concentrations in 2095 and fairly substantial reduction in the time during which aquifer concentrations exceed the MCL. Reducing anthropogenic water losses affects Sr-90 arrival north and south of the tank farm. Immobilizing Sr-90 in the alluvium has a modest affect on the long-term transport to the aquifer. If these results could be linearly superposed, the peak concentration would be about 7 pCi/L. However, because the Big Lost River infiltration affects transport primarily north of the tank farm, immobilizing the remaining Sr-90 affects Sr-90 concentrations directly beneath the tank farm, and the anthropogenic water is widely distributed throughout INTEC, the combined effect is only 12.5 pCi/L. Under this scenario, the MCL is achieved by year 2110, which is 19 years earlier than predicted in the RI/BRA base case.

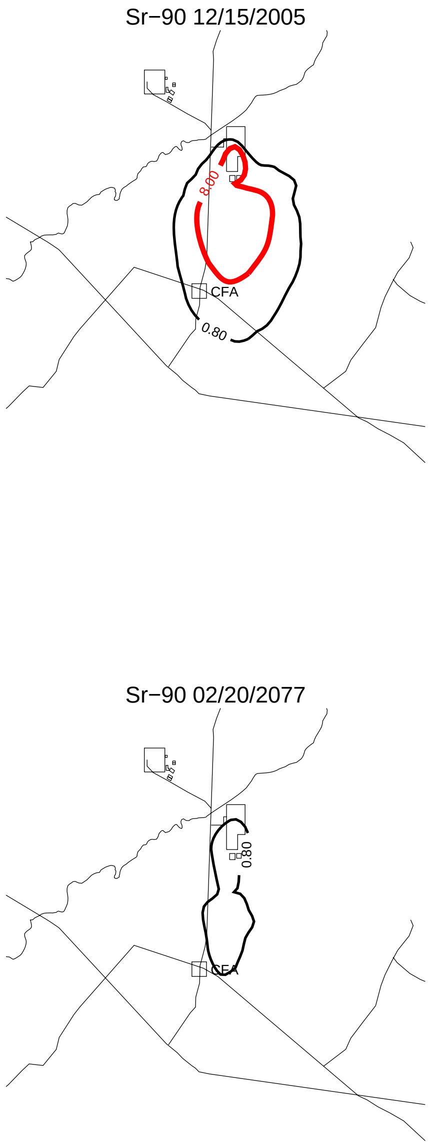

Figure A-10-1. Aquifer concentrations preventing infiltration from the Big Lost River, reducing anthropogenic water losses by 50%, and also immobilizing Sr-90 in the tank farm alluvium (horizontal contours) (pCi/L) (MCL = thick red line, 10*MCL=thin red line, MCL/10 = black line).

Figure A-10-2. Aquifer concentrations preventing infiltration from the Big Lost River, reducing anthropogenic water losses by 50%, and also immobilizing Sr-90 in the tank farm alluvium (horizontal contours) (pCi/L) (continued) (MCL = thick red line, 10*MCL=thin red line, MCL/10 = black line).

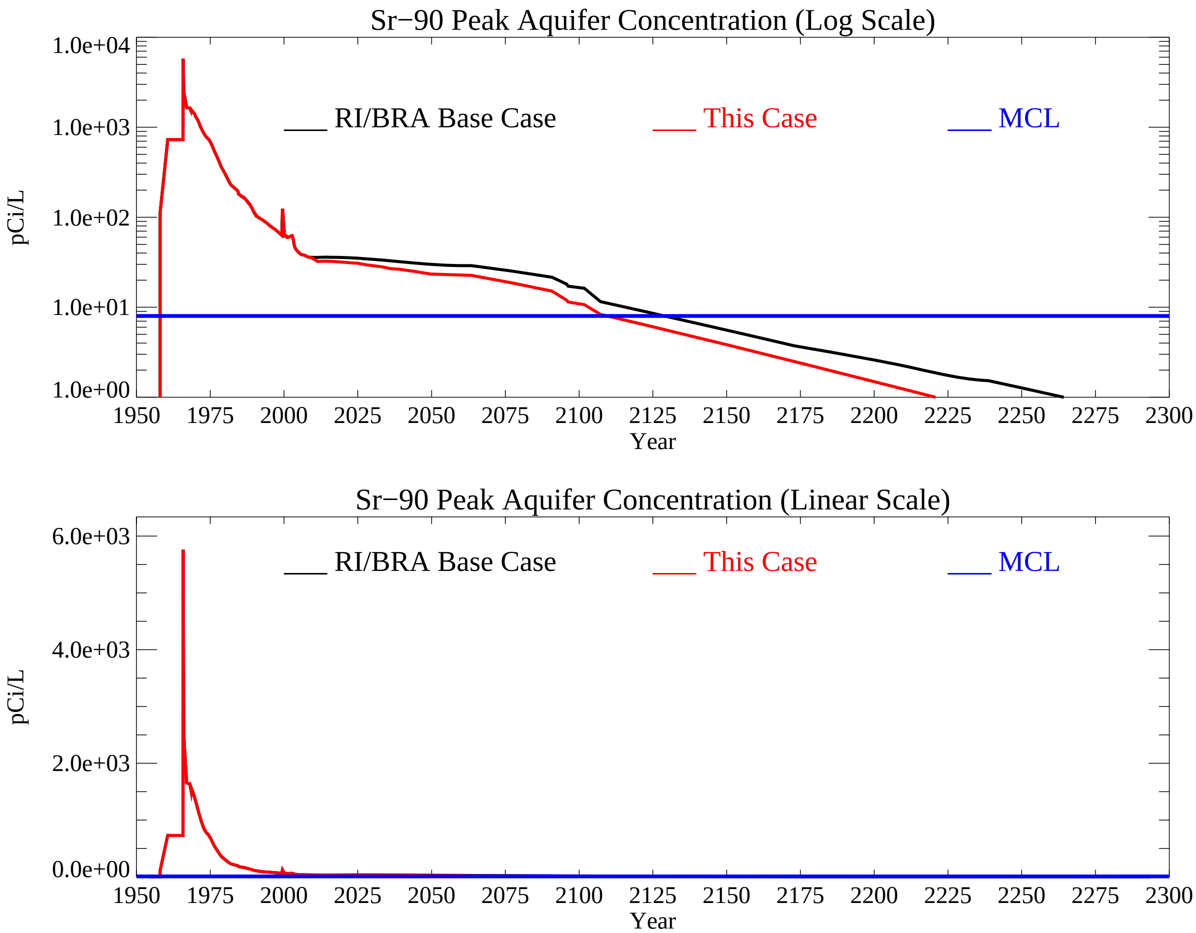

Figure A-10-3. Peak aquifer concentrations preventing infiltration from the Big Lost River, reducing anthropogenic water losses by 50%, and also immobilizing Sr-90 in the tank farm alluvium (pCi/L) (MCL = blue line, model predicted = black line [base case] and red line [this case]).

A-11 COMPLETE REMEDIATION OF THE SRPA VIA AQUIFER PUMP AND TREAT

Concentrations in the SRPA were predicted to exceed the MCL beyond year 2095 as a result of the former injection well, CPP-31, CPP-79 deep, OU 3-13 soil sources, and other OU 3-14 soil sources. The purpose of this simulation is provide an estimate of the volume of water and number of wells needed to bring aquifer concentrations below the MCL by the year 2095 and to maintain concentrations below the MCL beyond year 2095 by pumping water from the SRPA. Locations and durations adversely impacted by Sr-90 are dictated by the several different sources of Sr-90. As a result, the number of wells, well placement, and pumping rate will need to be spatially and temporally variable.

To account for the multiple sources, the aquifer can be remediated using two pumping periods and three wells. To determine well locations, the location of the peak aquifer concentration through time was determined. This location varies with plume location in the horizontal plain and required three well locations. For simplicity, all three wells were assumed to be completed between the water table and the top of the HI interbed. Pumping rates for the wells were all equal, but different pumping rates were applied to an early and late pumping period. The rate was determined such that concentrations in the aquifer are reduced below 8 pCi/L beyond year 2095. These rates and locations were chosen through manual iteration and do not represent a mathematically optimal solution.

The three well locations are illustrated in Figure A-11-1. In order to reduce the Sr-90 concentrations below 8 pCi/L, it will require initially pumping these three wells at a combined production rate of 550 gpm. Produced concentrations are quite low given that the aquifer concentrations are just above the MCL in that region of the aquifer during the 2077-2102 time period. Later in time, the two northern wells can capture Sr-90 arriving from the vadose zone with these wells pumping at a lower rate. They are pumped during the 2102-2123 time period at a combined rate of 183 gpm. Pumping the northern wells longer than year 2095 is required because simulated concentrations arriving in the aquifer from the tank farm continue beyond year 2095. This longer time period is also required to remove several pore volumes in order to counter adsorption processes in the aquifer.

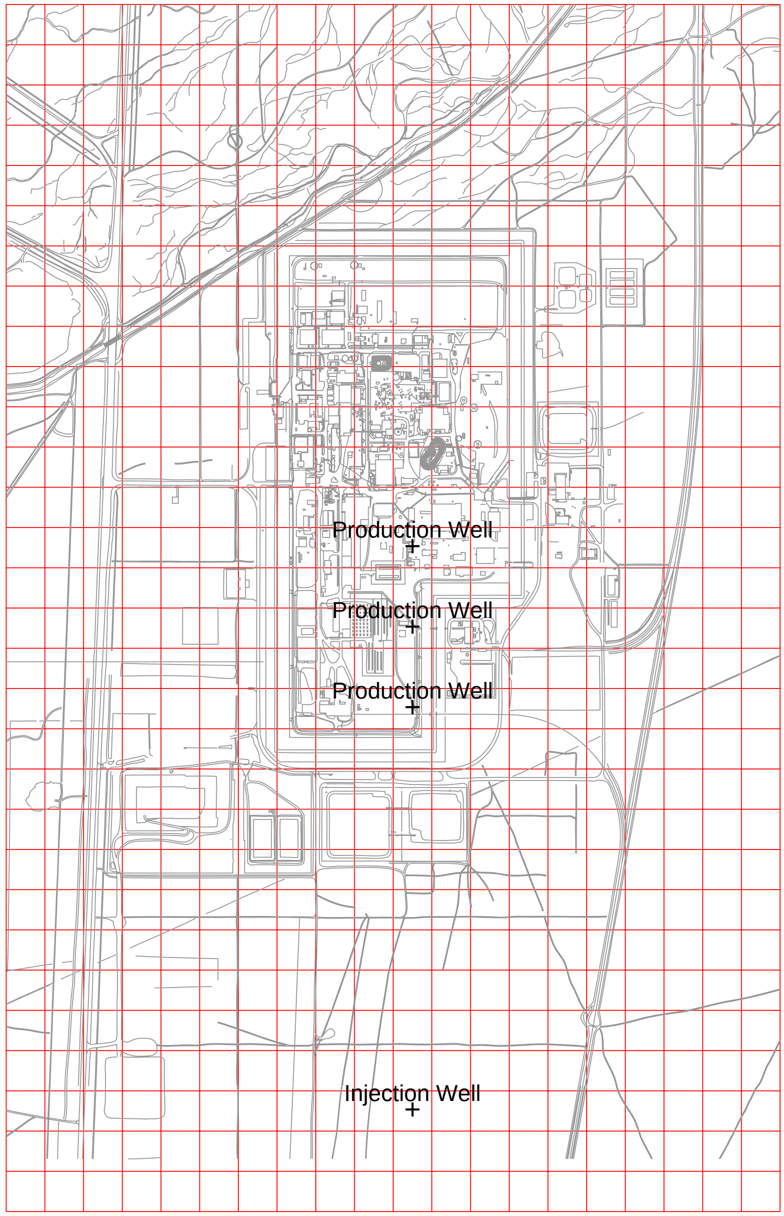

Figure A-11-1. Pump and treat for complete remediation well locations.

A-11-1 Aquifer Sr-90 Simulation Results

The distribution from 1979 through 2096 is shown in Figure A-11-2 on the coarse grid. Predicted concentrations on the fine grid for the 2049-2151 time period are given in Figure A-11-3. Pumping does not begin until year 2077, so subplots during this time are identical to the RI/BRA base case. The fourth subplot in Figure A-11-2 and the third subplot on Figure A-11-3 are for the year 2096 computed on the base aquifer grid and the refined aquifer grid, respectively. The peak concentration in 2095 is 7.8 pCi/L as shown in Figure A-11-4, with this area just below the MCL, and highest concentrations located north of the former percolation ponds.

Predicted peak concentrations are identical between the RI/BRA base case (black line in Figure A-11-4) and in this pumping case (shown in red) through year 2077 when pumping begins. There is a steep reduction in peak concentration between the 2077 and 2095 time period when all wells are primarily targeting Sr-90 originating from direct injection. In 2102, the rate at which the peak concentrations is declining is reduced following the removal of the southern well and decrease in overall production rate. Concentrations are well below the MCL through year 2123.

To illustrate why these wells need to remain in operation after year 2095, Figure A-11-4 is included. It corresponds to the case where the same three wells are used but with the remediation pumps turned off in year 2095. The rebound in aquifer concentrations is caused by the continued arrival of Sr-90 from the vadose zone that allows aquifer concentrations to rebound to the values predicted in the RI/BRA base case. In order to keep concentrations at or below the MCL, pumping has to continue as long as these fluxes are larger than the rate of natural attenuation (dilution, dispersion, adsorption, and decay) in the aquifer.

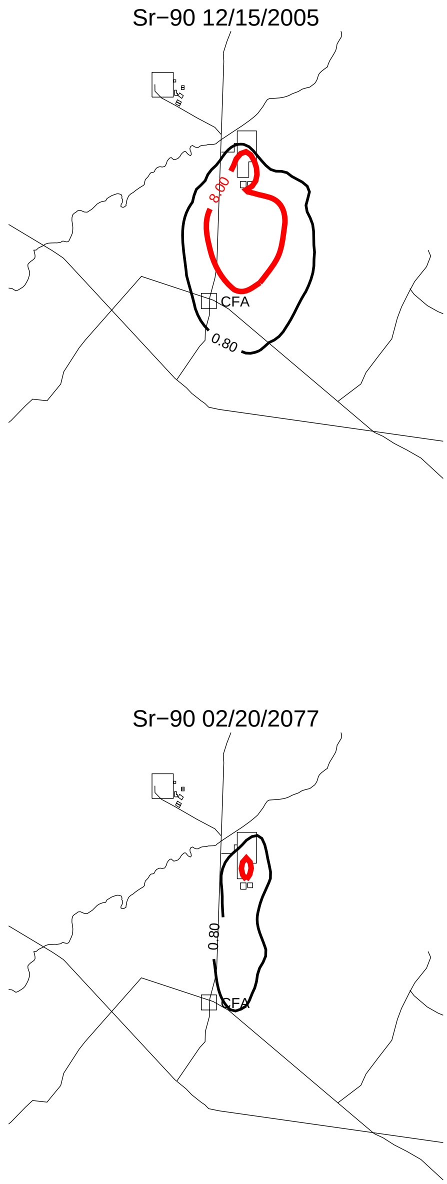

Figure A-11-2. Aquifer concentrations (horizontal contours) (pCi/L) pumping for complete remediation (MCL = thick red line, 10*MCL=thin red line, MCL/10 = black line).

Figure A-11-3. Aquifer concentrations (horizontal contours) (pCi/L) pumping for complete remediation (continued) (MCL = thick red line, 10*MCL=thin red line, MCL/10 = black line).

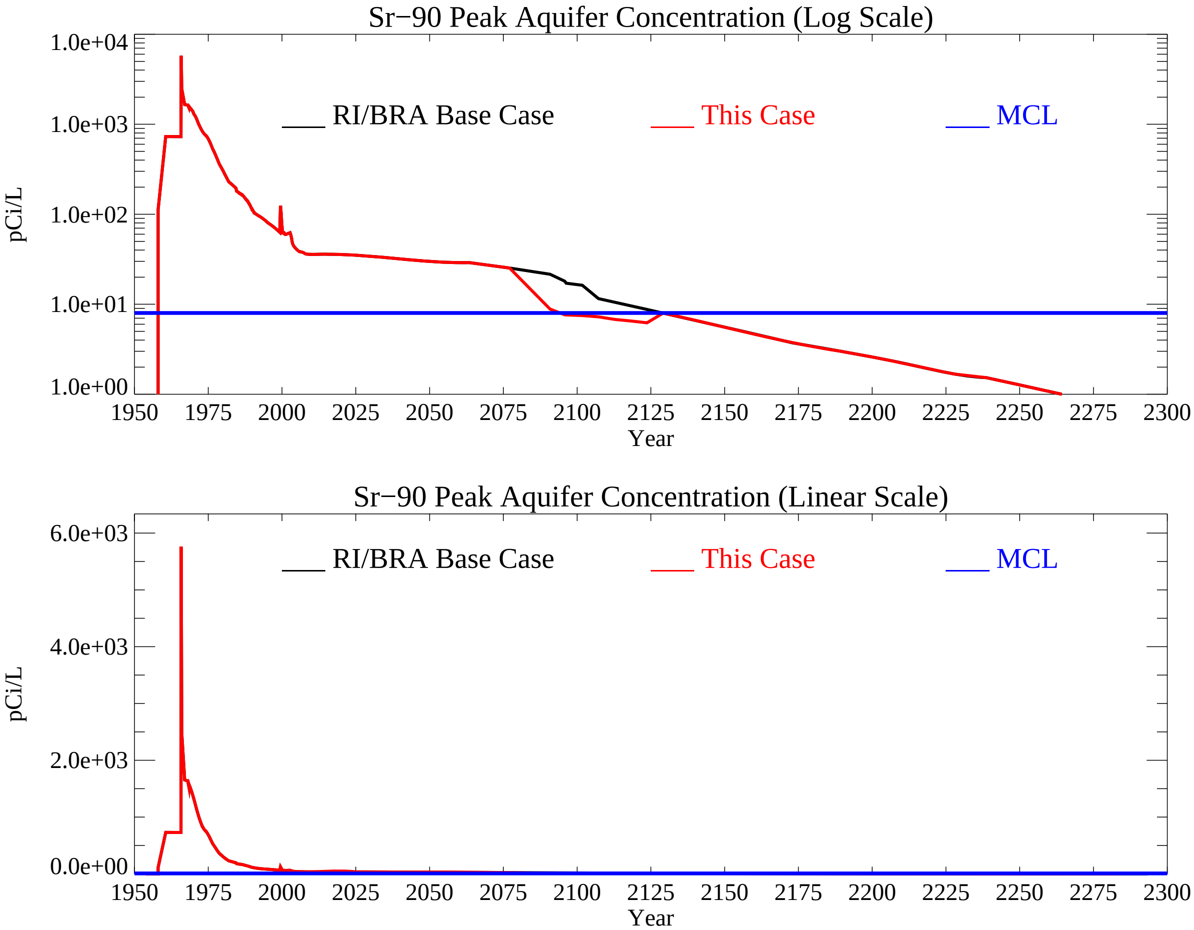

Figure A-11-4. Peak aquifer concentrations (pCi/L) pumping for complete remediation with pumps operational through year 2123 (MCL = blue line, model predicted = black line [base case] and red line [this case]).

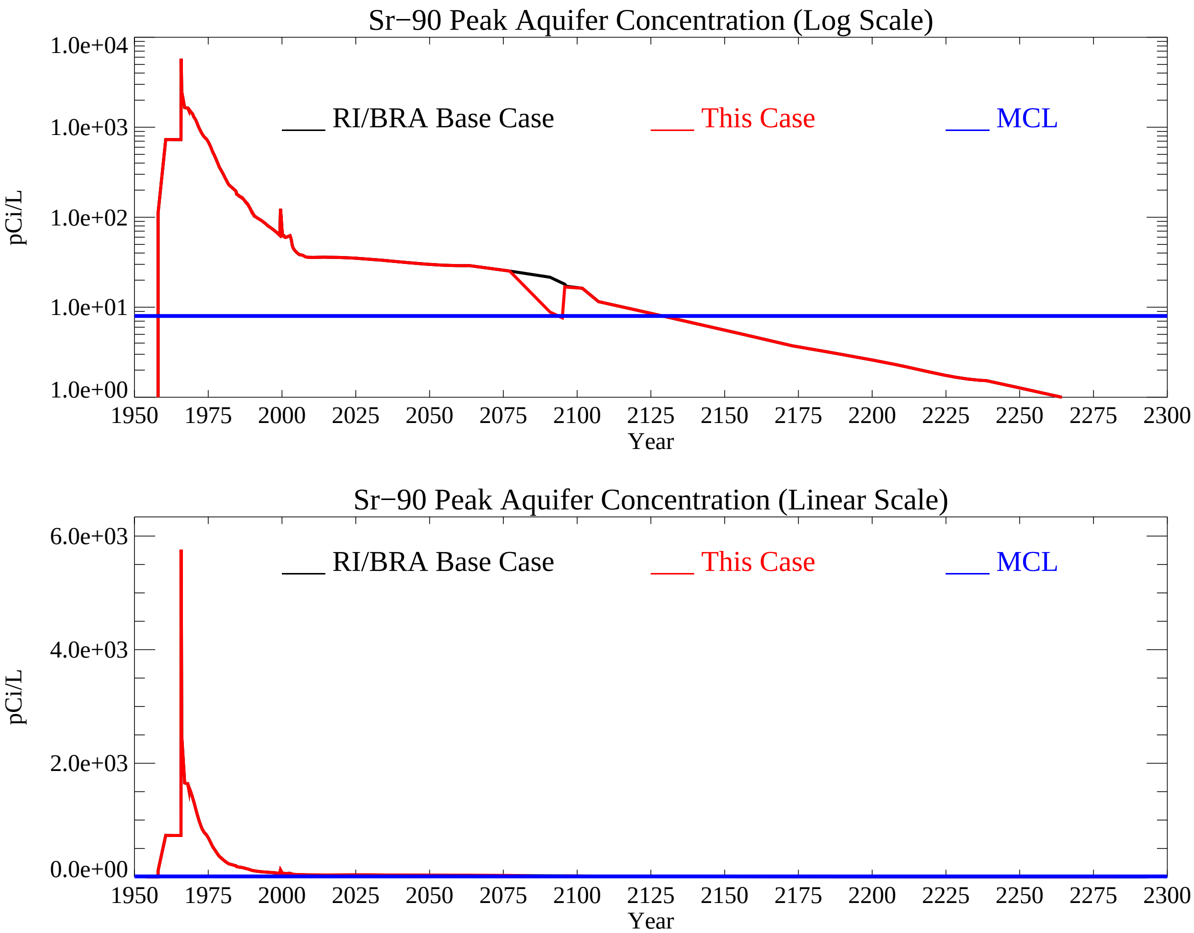

Figure A-11-5. Peak aquifer concentrations (pCi/L) pumping for complete remediation with pumps turned off in year 2095 (MCL = blue line, model predicted = black line [base case] and red line [this case]).

A-12 SUMMARY

This study has evaluated various alternatives for reducing concentrations of Sr-90 in the SRPA. Results presented here were based on the RI/BRA base model presented in Section A-8 of the RI/BRA [DOE-NE-ID 2006]. The simulations presented factored in potential perched water controls that are the responsibility of OU 3-13 Group 4 in addition to examining OU 3-14 specific actions on the alluvial sediments and on the aquifer. Qualitatively, we note the overall behavior and add a discussion relative to the most sensitive parameters found in the RI/BRA:

- Reducing anthropogenic water losses by 50% by year 2008 results in a 22% decrease in peak 2095 aquifer concentrations. This percentage is slightly higher in the 2010-2095 time period, but by 2110, the peak concentration is quite similar to the RI/BRA base case prediction. The convergence in concentration occurs because (a) it is assumed that anthropogenic water losses completely cease in 2095 in the base case and (b) the flux rate from the vadose zone is higher than natural attenuation processes in the aquifer. The short-term gains in aquifer concentration achieved by reducing anthropogenic water early do not persist as shown by the 7-year reduction in time during which the MCL is exceeded. Further, the area affected by the reduction in flux rates is quite small.

  These results are somewhat sensitive to interbed or alluvium K_d. If the interbed K_d is higher, the reduction in concentration will be smaller because the Sr-90 is more concentrated in an area beneath the tank farm, and the anthropogenic water is distributed throughout INTEC. If the interbed K_ds are lower than assumed in the RI/BRA base case, reducing anthropogenic water will be more effective in reducing predicted aquifer Sr-90 concentrations because the Sr-90 will be more widely distributed in the vadose zone and more highly affected by the spatially distributed anthropogenic water.

  These results will be very sensitive to the assumed distribution and volume of anthropogenic water losses. For example, if the anthropogenic water losses are actually focused in northern INTEC, this action could achieve significant reductions in predicted aquifer concentrations. Although higher anthropogenic water fluxes in northern INTEC will also result in higher aquifer concentrations, reducing the fluxes by 50% could have a very large impact.

- Eliminating infiltration from the central reach of the Big Lost River reduced the peak aquifer concentration in year 2095 by only 5.9%. More importantly, decreasing fluxes in northern INTEC significantly reduced the size of the area impacted by concentrations between the 0.8 pCi/L and 8.0 pCi/L levels. It also reduced the time period during which Sr-90 exceeded the MCL by 8 years. However, removing this flux source did not greatly affect aquifer concentrations underlying central INTEC. In this case, substantive decreases in predicted peak aquifer concentration do not occur until the 2090 timeframe. These gains persist after 2095 because we assume that the infiltration from the Big Lost River can be stopped even after 2095.

  This result is sensitive to the interbed K_d. If the interbed K_d is higher, removing this flux source will have even less effect. A smaller interbed K_d allows much more northward migration of Sr-90 while in the upper vadose zone and results in concentrations exceeding the MCL in the aquifer in an area to the northeast of the tank farm. In the smaller interbed K_d scenario, removing the Big Lost River fluxes will have a significant impact on the overall distribution of Sr-90 in year 2095 and beyond.

  This result is also sensitive to the assumed distribution and volume of anthropogenic water losses. The distribution of Sr-90 is more toward the north when more water is applied to northern INTEC. Removing the Big Lost River fluxes in that case allows slower migration and lower concentrations of Sr-90 in the aquifer relative to the case in which the flux is not removed. However, removing these fluxes if there is more northern anthropogenic water in the base case would not result in concentrations lower than 8 pCi/L in 2095.

- Immobilizing the Sr-90 remaining in the alluvium in the year 2008 resulted in a 9.1% decrease in peak 2095 aquifer concentrations. By year 2122, concentrations were predicted to fall below the MCL. During this time, the area impacted above the MCL was very close to that predicted in the base case. Following the initial release of Sr-90 from Site CPP-31, the resulting alluvium pore water returns to ambient conditions with a corresponding increase in adsorptive potential on cation exchange sites. The resulting increase in K_d is sufficient to self-immobilize the residual Sr-90. The degree to which this occurs decreases with decreasing cation exchange capacity accompanied by a decrease in the amount of Sr-90 remaining in the alluvium. The competing effect of less Sr-90 remaining in the alluvium and slight increase in mobility was examined explicitly. Decreasing the cation exchange capacity from 7 meq/100 g to the RI/BRA model value of 2 meq/100 g almost tripled the peak concentration and also increased the amount of Sr-90 initially released to the perched water by a factor of two. It was shown in the RI/BRA that the Sr-90 remaining in the alluvium does not significantly contribute to peak aquifer concentrations and that immobilizing tank farm Sr-90 produces relatively small gains.

  Immobilizing the Sr-90 in the alluvium does not change the fundamental migration out of the perched water. As observed in Appendix J of the RI/BRA, [DOE-NE-ID 2006], the interbed K_d affects the Sr-90 already in the perched water. As a result, increases in interbed K_d will slow Sr-90 migration and will reduce aquifer concentrations relative to a base parameterization. As predicted in Appendix J of the RI/BRA [DOE-NE-ID 2006], increasing the anthropogenic water losses in northern INTEC will increase migration out of the perched water.

- Reducing infiltration through the 10 acres surrounding the tank farm results in the greatest decrease in aquifer concentrations because it removes the downward driving force carrying high-concentration Sr-90 currently in the perched water. Essentially vertical transport downward from the tank farm results in high concentrations directly beneath and to the southeast of the tank farm. Most of the Sr-90 predicted to be in the northern upper perched water originated from CPP-79 deep and CPP-31 and was released into the perched water rapidly. Eliminating the 18-cm/yr infiltration through the 10-acre tank farm area resulted in a 58% reduction in peak aquifer concentration in year 2095 and allowed the aquifer concentrations to fall below the MCL 34 years earlier than predicted in the RI/BRA base case. It is important to realize that these gains were achieved by removing the infiltration as opposed to immobilizing Sr-90. It illustrates that any flux removal action should target areas overlying high concentrations in the perched water.

  If the interbed K_d is lower than assumed in the RI/BRA model, more Sr-90 will migrate away from the point of release. In that case, reducing infiltration in the 10 acres surrounding the tank farm might be less effective. To achieve the same effectiveness as predicted here, a larger cap might be required, with the cap extending to the northeast.

  Similarly, if the anthropogenic water losses are higher in northern INTEC than assumed in the RI/BRA model, reducing infiltration in the 10 acres simulated here would be less effective. The larger fluxes would result in more lateral spreading of Sr-90, probably to the southeast, and would require infiltration controls over that area.

- Combining flux reduction in the Big Lost River with anthropogenic water controls does not produce a linearly additive effect. The Big Lost River primarily affects concentrations north of the tank farm, and the anthropogenic water is distributed throughout INTEC. Reductions in concentrations after removing the Big Lost River fluxes occur late in time, while concentrations are reduced immediately following anthropogenic water controls. The spatial offset and temporal differences result in nonadditive effects. Under this scenario, the peak 2095 concentration is reduced by 27%, and the MCL is achieved 14 years earlier than predicted in the RI/BRA base case. Although not a linearly additive effect, the combined water reduction actions result in improvements over each action alone.

A higher interbed K_d would decrease the additiveness of this remedy because it decreases the impact of the Big Lost River. Higher anthropogenic water losses would increase the net effect because more lateral migration in the interbeds results in higher northern INTEC aquifer concentrations, which are affected by the Big Lost River.

- <u>Reducing the anthropogenic water by 50% in addition to reducing infiltration through 10 acres surrounding the tank farm</u> results in a 65% reduction in peak aquifer concentrations and allows the MCL to be achieved 38 years earlier than predicted in the RI/BRA base model. The combined effect is also not linearly additive because the anthropogenic water is assumed to be distributed throughout INTEC, including the tank farm area. Capping the 10 acres surrounding the tank farm accounts for the anthropogenic water infiltrating through the tank farm. The combined effect does not remove that water twice. This combination produces one of the most effective overall decreases in both peak concentration and in time during which the MCL is exceeded.

  If the interbed K_d is higher than assumed here, the combined effect will be less additive, and the effect would approach that of simply reducing infiltration through the 10-acre area around the tank farm. If the interbed K_d is smaller, the Sr-90 is more mobile, it moves out laterally, and the combined action of removing anthropogenic water and capping the tank farm will be more effective than simply reducing infiltration through the 10-acre area surrounding the tank farm.

  Increased anthropogenic water losses in northern INTEC would allow this combined action to be more effective than just capping the tank farm. This is because higher anthropogenic water losses move the Sr-90 out from under the tank farm and makes it subject to higher anthropogenic flux rates. Reducing infiltration through the 10 acres surrounding the tank farm in addition to removing the higher anthropogenic water losses would be significant.

- <u>Reducing infiltration from the Big Lost River in addition to reducing infiltration through the 10 acres surrounding the tank farm</u> is less additive than the combination of reducing river fluxes and anthropogenic water. The reasons are again because the Big Lost River primarily affects concentrations north of the tank farm, and the fluxes near the tank farm affect aquifer concentrations to the south of the tank farm. Reductions in concentrations after removing the Big Lost River fluxes occur late in time, while concentrations are reduced immediately after capping the tank farm. The spatial offset and temporal differences result in nonadditive effects. Under this scenario, the peak 2095 concentration is reduced by 60.7%, and the MCL is achieved 35 years earlier than predicted in the RI/BRA base case. Although not a linearly additive effect, the combined water reduction actions result in improvements over each action alone.

  A higher interbed K_d would decrease the additiveness of this remedy because it decreases the impact of the Big Lost River. Higher anthropogenic water losses would increase the net effect because more lateral migration in the interbeds results in higher northern INTEC aquifer concentrations, which are affected by the Big Lost River.

- <u>Reducing infiltration from the Big Lost River, reducing infiltration through the 10 acres surrounding the tank farm, and reducing anthropogenic water losses by 50%</u> are only slightly more effective than just considering the last two water reductions together. Adding Big Lost

River controls would be more important and would result in faster decreases in Sr-90 concentrations if the interbed K_d is smaller than assumed here. It is not immediately apparent if that would be true if the anthropogenic water losses are higher than assumed in northern INTEC.

- Adding immobilization of Sr-90 in the alluvium to Big Lost River flux controls and anthropogenic water controls only slightly improves the results obtained through the two flux control measures.
- Remediating all of the SRPA to levels below the MCL by year 2095 is going to require pumping large volumes of water for extensive time periods. For sorbing contaminants, equilibrium conditions are maintained between the amount of Sr-90 on the solid phase and Sr-90 in the aqueous phase. In order to remove all of the sorbed Sr-90, several pore volumes are required. In the case of complete remediation by year 2095, the footprint of Sr-90 is quite large, requiring several wells. The combination of pore volume per well and numbers of wells results in a large pumped volume. As Sr-90 continues to arrive from the vadose zone, pumping rates must be maintained above the levels of natural attenuation in order to keep concentrations below the MCL. This requires that pumping be maintained beyond 2095.

  If the interbed K_d is lower than assumed in the RI/BRA model, the plume above 8 pCi/L will be much larger than predicted here. It will require longer pumping times and higher rates. If the anthropogenic water losses are higher in northern INTEC, peak aquifer concentrations are significantly higher than predicted in the RI/BRA model, and the plume is much more extensive.

The results of simulations presented here are summarized in Table A-12-1 for two of the performance measures:

- Peak aquifer concentration in 2095 is summarized in Column 3.
- The year in which concentrations are predicted to be below the MCL of 8 pCi/L is given in Column 4.

Based on these simulations, several combined actions affecting the vadose zone will result in concentrations meeting the MCL in 2095.

Feasibility Simulation	Document Section	2095 Peak Aquifer	$C_{Sr-90} \leq 8\ pCi/\mathrm{L}$	
		Concentration (pCi/L)	Year	Years Different
RI/BRA base case [DOE-NE-ID 2006]		18.6	2129	
Reducing anthropogenic water recharge by 50%	A-2	14.4	2122	7
Preventing infiltration from the Big Lost River	A-3	17.5	2103	26
Immobilizing Sr-90 in the tank farm slluvium	A-4	16.9	2122	7
Reducing infiltration through the 10 acres surrounding the tank farm	A-5	7.9	2095	34
Preventing infiltration from the Big Lost River in addition to reducing anthropogenic water recharge by 50%	A-6	13.5	2115	14
Preventing infiltration from the Big Lost River in addition to reducing infiltration through the 10 acres surrounding the tank farm	A-7	6.5	2091	38
Reducing anthropogenic water recharge by 50% in addition to reducing infiltration through the 10 acres surrounding the tank farm	A-8	7.3	2094	35
Preventing infiltration from the Big Lost River, reducing anthropogenic water recharge by 50%, and reducing infiltration through the 10 acres surrounding the tank farm	A-9	6.0	2089	40
Preventing infiltration from the Big Lost River, reducing anthropogenic water recharge by 50%, and immobilizing Sr-90 in the tank farm alluvium	A-10	12.5	2110	19
Aquifer pump and treat for complete remediation	A-11	7.8	2094	35

Table A-12-1. Summary of feasibility simulations.

A-13 REFERENCES

DOE-NE-ID, 2006, *Operable Unit 3-14 Tank Farm Soil and Groundwater Remedial Investigation/Baseline Risk Assessment*, DOE/NE-ID-11227, Rev. 0, U.S. Department of Energy Idaho Operations Office, April 2006.